Active Project (2015 - 2017)

Automated Manufacture of Damage Detecting, Self-Healing Composite Cryogenic Pressure Vessels, Phase II Project

SBIR/STTR Programs | Space Technology Mission Directorate (STMD)

ABSTRACT

After successfully demonstrating the basic functionality of a damage-detecting, self-healing 'smart' material system in Phase I, Aurora and UMass Lowell aim to advance the material technology to a TRL 5 in Phase II. The team will use their 'smart' material system to design and manufacture various scaled-up core-stiffened composite specimens in application-appropriate geometries, and subsequently test the specimens in a simulated operational environment that includes hypervelocity impact to simulate MMOD impacts, and thermal cycling to represent the large temperature gradients in space. Aurora and UMass Lowell will automate the resistive heating process by relying on changes in the flow of heat through the material as measured by sending electrical current through the structure and monitoring using infrared thermography. Based on the extent of damage, additional heat can be automatically triggered to accelerate healing. The team will consider the integration of the 'smart' material into a larger system in Phase II, including the storage of fluid within the honeycomb core cells to re-fill micro-channels. Vertically aligned carbon nanotubes (VACNTs) from N12 Technologies, Inc. will be continuously transfer-printed onto the carbon fiber prepreg slit tape and spooled for automated fiber placement (AFP). When laid down by AFP, the VACNTs will "stitch" adjacent layers together to reinforce the interlaminar region and improve the damage tolerance of the overall structure with a negligible increase in weight and thickness. At the end of Phase II, the team will work with NASA Langley Research Center's new Integrated Structural Assembly of Advanced Composites facility to manufacture a scaled pressure vessel that will be damaged via hypervelocity impact multiple times to evaluate its self-healing performance. This scaled demonstration will enable the team to define further scale-up requirements and make cost and performance predictions for subsequent development phases.

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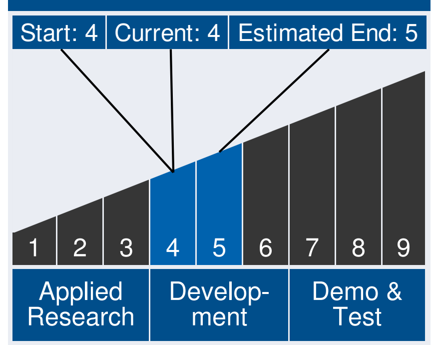
Technology Maturity



Management Team

Program Executives:

- Joseph Grant
- Laguduva Kubendran

Program Manager:

- Carlos Torrez

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ANTICIPATED BENEFITS

To NASA funded missions:

Potential NASA Commercial Applications: The developed "smart" material has several applications within NASA. First, the smart aspects are integrated with a commercially available OOA prepreg material suitable for large, lightweight composite structures. Second, this material is compatible with AFP for cost-effective, rapid manufacture of such large, lightweight structures. Furthermore, the implementation of the smart aspects is done using automated, controlled processes. The microvascular channels for self-healing are fabricated using a FDM print-head that can be interfaced with the AFP machine, while the CNTs are transferred continuously to prepreg slit tape and spooled prior to AFP. This combination of materials and manufacturing processes lends itself attractive for applications within NASA's Space Exploration program such as large pressure vessels, vehicles, and habitat modules. The lifetime and reliability of these structures will be improved as they become larger and lighter weight, and are sent deeper into space for future missions. Clearly, after these structures are launched into space, it is often not practical to service them in the event of any damage. The ability to detect damage and to self-heal will be advantageous in such cases. With the success of this STTR program, Aurora will have positioned itself to compete for future NASA contracts that require the manufacture of large, composite space structures similar to the Orion heavy lift launch vehicle, the SLS, and NASA's COTS vehicle.

To the commercial space industry:

Potential Non-NASA Commercial Applications: As an aerospace company, Aurora designs, develops, and manufactures various primary and secondary composite structures for unmanned and manned, military and commercial aircraft. The structures, over repeated load cycles, will develop cracks that affect performance and require significant downtime and maintenance. Being able to integrate damage detection and self-healing

Management Team *(cont.)*

Principal Investigator:

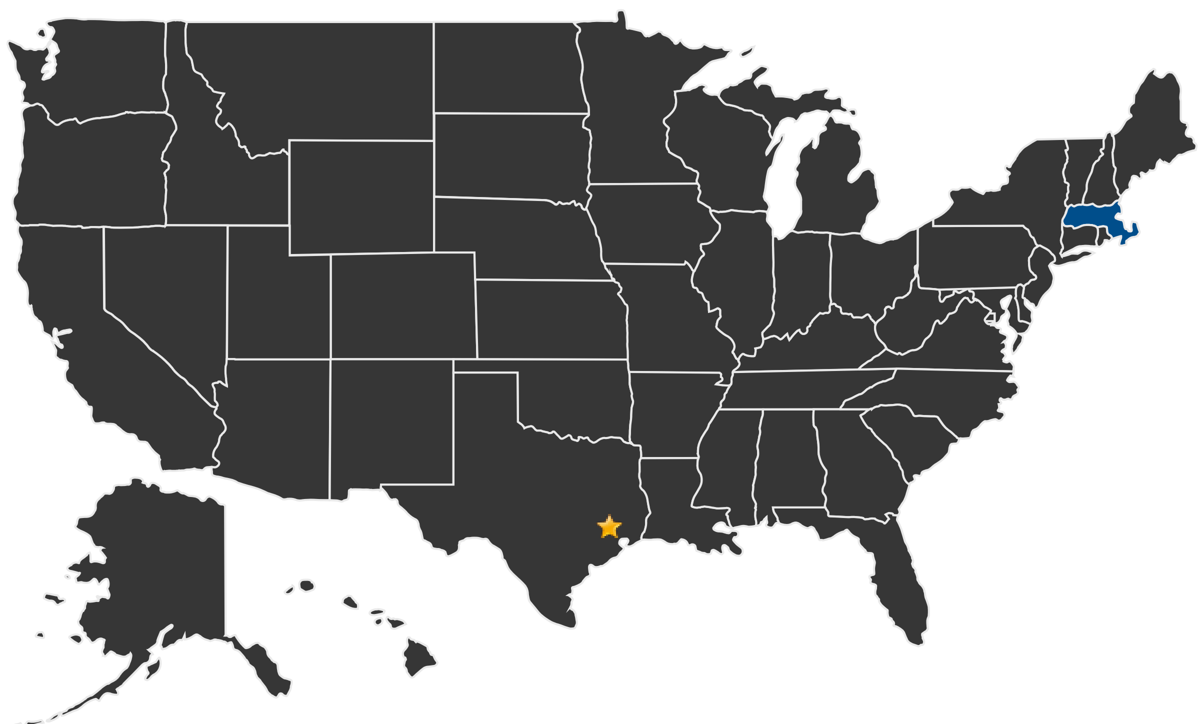
- Konstantine Fetfatsidis

Technology Areas

Primary Technology Area:
Nanotechnology (TA 10)
└ Engineered Materials and Structures (TA 10.1)
  └ Damage-Tolerant Systems (TA 10.1.2)

capabilities with these structures will position Aurora to offer innovative new, "smarter" designs for commercial customers, that are more lightweight and damage tolerant. Aurora is already working on an application that detects damage and dynamically adjusts its flight parameters (e.g. lower altitude, different speed, etc.) to maximize performance prior to grounding for repairs. A self-healing system would enable the aircraft to fly for a longer period of time and complete its required mission without unnecessarily grounding the aircraft for maintenance and repairs. Furthermore, Aurora could leverage its relationship with major prepreggers such as Cytec, Hexcel, TenCate, and Toray to license the "smart" material out for subsequent sales to other industries including wind energy, automotive, and construction (e.g. buildings and bridges).

U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Johnson Space Center

Other Organizations Performing Work:

- University of Massachusetts - Lowell (Lowell, MA)

PROJECT LIBRARY

Presentations

- Briefing Chart
  - (http://techport.nasa.gov:80/file/20302)

DETAILS FOR TECHNOLOGY 1

Technology Title

Automated Manufacture of Damage Detecting, Self-Healing Composite Cryogenic Pressure Vessels